CALIFORNIA ISO

California Independent
System Operator

Market Based Simulation in the CAISO Transmission Evaluation Assessment Methodology (TEAM)

CEC IERP Workshop on 2004 Transmission Update
June 14, 2004

Mingxia Zhang, Ph.D.
Principal Economist

CAISO Market Analysis

Market Based Simulation

- Issue: How generators' bidding behavior should be modeled in a wholesale market regime?
- Traditionally, cost-based bidding
- Historical evidences indicate that generators might bid above their marginal costs
- More importantly, transmission expansion can enhance market competitiveness and our methodology should capture this benefit

Market Based Simulation

- Goal is to perform transmission evaluation based on market prices rather than traditional cost-based analysis.
- More specifically, to model suppliers' strategic bidding behavior and how their bidding behavior changes with the transmission upgrade.

Market Based Simulation

- Modeling strategic bidding is difficult
  - Game theoretical approach
    - Cournot-Nash game (physical withholding)
    - Supply function equilibrium (economic withholding)
    - These methods are difficult to implement in a complex network model
  - Empirical approach
    - Regression relates price-cost mark-up with Residual Supply Index
    - Regression parameters estimated for California
    - Parameters for outside control areas could be based on backcast simulation and calibration (or regression analysis)
    - Can be applied to zonal configuration of network models
    - Can be applied with calibration to nodal network models

An Empirical Approach to Model Strategic Bidding

- Develop historical relationship (regression) between price-cost markups and certain system conditions.
- Use the regression results to predict bid-cost markups under future system conditions.
- Apply the bid-cost markups to the supply bids and run the model to determine dispatch and market clearing prices.
- Note:
  - Historical Price-Cost Markups are based on the difference between actual zonal market prices and estimated competitive prices.
  - Bid-Cost Markups are estimated and used prospectively in the transmission study. Bid-Cost Markups reflect the difference between the variable cost of a generating unit and a market-based bid.

Price-Cost Markup Regression Results

- Estimate relationship between price-cost markups (PMU) and system conditions
  - Using hourly data covering Nov-99 to Oct-00 and 2003.
  - The price-cost markup (PMU) is expressed as the Lerner Index.
  - Lerner Index at region ***i*** and hour ***t*** is:

    $PMU_{it}=(P_{it}-C_{it})/P_{it}$

    where P_{it} = Actual price in region *i* and hour *t*

    C_{it} = Estimated competitive price in region *i* and hour *t*
  - System conditions are represented by several key variables (e.g., RSI, % of Un-hedged load, etc.)

Residual Supply Index (RSI)

- A Residual Supply Index provides a good measure on the extent to which the largest supplier in the market is "pivotal" to meeting demand.

$$RSI = \frac{(\text{Total Supply} - \text{Largest Supplier's Supply})}{\text{Total Demand}}$$

- An RSI value less than 1 indicates the largest supplier is pivotal in meeting demand.
- In the CAISO markets, RSI values less than 1.2 have generally been associated with market prices in excess of estimated competitive levels.
- RSI can capture the impact of transmission upgrade on supply/demand balance.

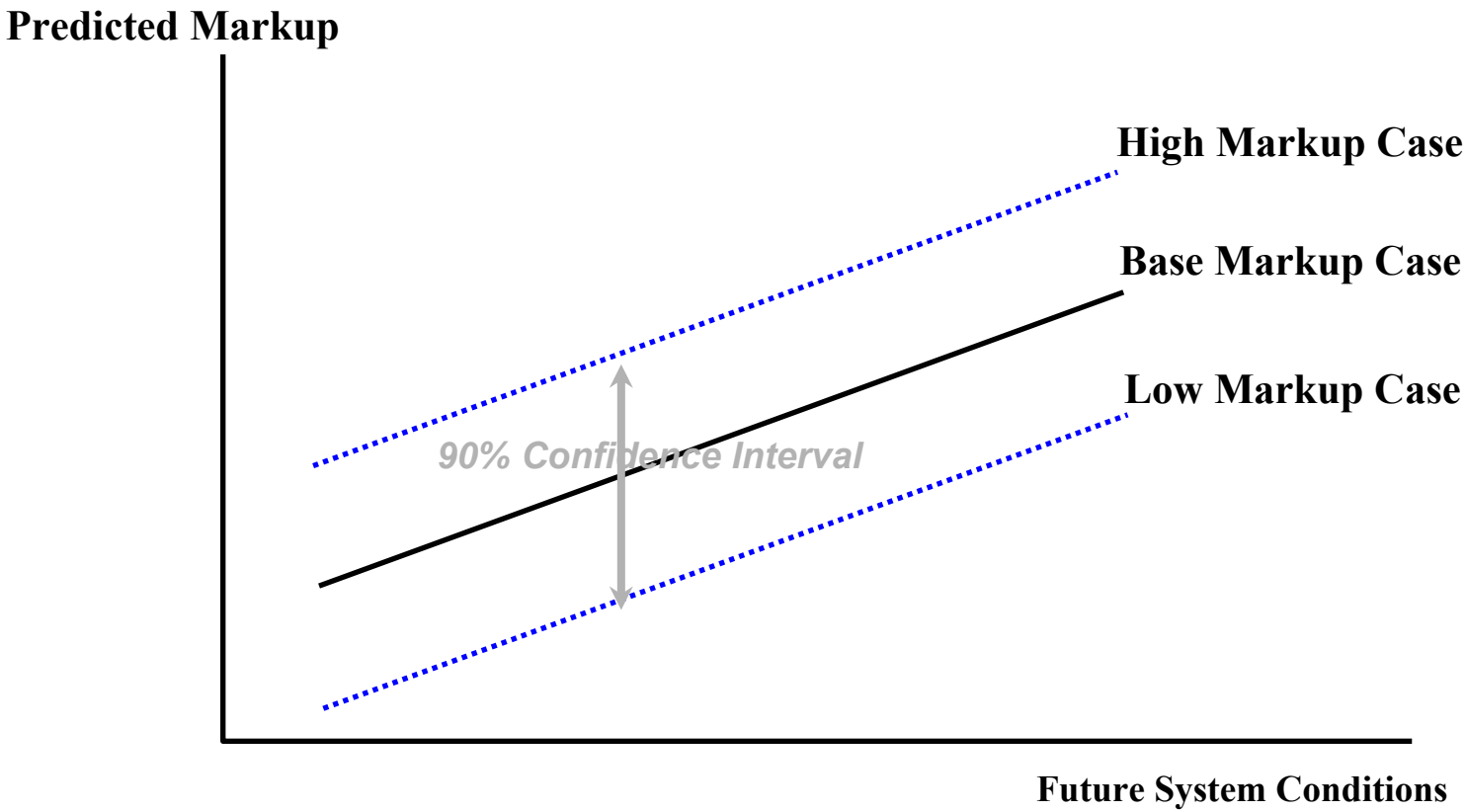
Regression Results

Dependent: Lerner Index	Model 1	Model 2
Intercept	0.14 [11.08]	0.57 [14.77]
RSI (gross RSI specification)	-0.53 [72.76]	-1.81 [35.55]
RSI_Square (RSI*RSI)		0.54 [27.75]
Pct_load_unhedged	0.65 [70.98]	0.6 [66.77]
Normalized Load (hourly load/annual average load)		0.4 [32.89]
Dummy for Peakhour	0.086 [23.77]	0.018 [4.00]
Dummy for Summer Months	0.15 [48.19]	0.1 [30.83]
R Squared	0.46	0.49
Number of Observations	31333	31333

Application of Regression Results to Predict Bid-Cost Markups

- Apply regression results prospectively to predict hourly price-cost markups in years 2008 and 2013.
- Use predicted price-cost markups as bid-cost markups.
- Markups are estimated separately for each hour and each demand region (i.e. PG&E, SCE, SDGE).
- 3 Levels of Bid-Cost Markups: Base, High, and Low.
- Base Markup Case: directly derived using regression coefficient estimates with some calibration.
- High and Low Markup Cases: derived based on 90% confidence intervals of predicted markups with some calibration.

High, Low, and Base Markup Cases



Implementing Bid-Cost Markup Approach in PLEXOS

- Bid-Cost Markup functionality is incorporated directly into PLEXOS
  - RSI and other determinants of predicted bid-cost markups can be computed internally in PLEXOS
  - The projected bid-cost markups can be automatically incorporated into the market-price run
  - The benefit computation can be computed directly in PLEXOS

Potential Future Enhancements to Market Price Modeling

- Further refinements to econometric approach
  - Regression based on "bid-cost" markups rather than "price-cost" markups
  - Refine the methodology to compute the competitive market clearing price
- Explore game theoretical approaches
  - Conjectural model (developed by London Economics)
  - Cournot model applied in the full network model
  - Supply Function Equilibrium approaches

Path 26 Case Study Results
2008, Base System Condition

	Cost-Based	Market-Based
WECC Total Societal Benefit (Production Cost Saving)	$ 1.00 M	$ 4.28 M
WECC Total Modified Societal Benefit	$ 1.00 M	$ 7.04 M
CAISO Participants Modified Benefit	$ 0.50 M	$ 11.99 M
CAISO Ratepayers Modified Benefit	$ 2.10 M	$ 19.00 M